"22"

Hydraulics

3^{rd} Year civil

First Term (2009 - 2010)

Chapter ( )

Revision Part (4)

final 2008

Zagazig University
Faculty of Engineering
Water & Water Str. Eng. Dept.

Final Exam. 19 Jan. 2008
Hydraulics1
Time allowed 4 hrs

Solve only five questions out of the given six

Questions no. 1 (20%)

a- List the factors affecting the velocity distribution in open channels.
b- Derive the dynamic equation for GVF in open channels.
c- Derive an expression for critical flow conditions in non-rectangular open channel cross section.
d- List the different methods for discharge measurements in open channels.
e- Explain the effect of hump height on the two alternate depths in a rectangular channel, using neat sketches diagram.

Question no. 2 (20%)

(i) The power P required by the pump is a function of discharge Q, H, g, viscosity μ, and mass density of the fluid ρ, speed of rotation N and impeller diameter D. Obtain the relevant dimensionless parameters, show details only for one parameter.

XX (ii) A centrifugal pump was tested in the laboratory by constructing a 1:8 scale geometrically similar model. The model consumed 5 KW power working at 5 m head and 450 rpm speed. If the prototype is to work under 80 m head, determine its power requirement, speed, and the discharge ratio.(Hint: you may use the dimensionless parameters resulted from part (i)).

Question no. 3 (20%)

(i) State the factors affecting the Manning's roughness coefficient.

(ii) A 3.0 m wide rectangular channel carries 2.4 cubic meter per second discharge at a depth of 0.7 m. Do the following:
(a) Determine specific energy at 0.7 m depth.
(b) Determine the critical depth.
(c) Is the flow subcritical or supercritical?
(d) Determine the depth alternate to 0.7 m.
(e) If Manning's n is 0.015, determine the critical slope.

Question no. 4 (20%)

(i) Based on both the normal and the critical depths, classify various surface profiles obtained in steady gradually varied flow in a prismatic channel.

(ii) Consider a trapezoidal channel of 4.0 m bottom width with side slopes of 1:1 and bottom slope of 0.00015. If it carries a discharge of 2.485 cubic meter per second with Manning's of 0.02, classify the profile and determine the distance required to change the flow depth from 0.90 m to 0.50 m, using the

direct step method and a two steps. Explain how to improve the accuracy of your computations.

Question no. 5 (20%)

a- List few uses of the hydraulic jump.

b- Derive an expression for the energy loss through the hydraulic jump formed on horizontal smooth channel bed.

c- Water flows over the spillway of a dam at a head of 2.73 m. The difference of elevation between spillway crest and downstream bed level is 30 m. If the discharge coefficient of spillway is 0.75, determine the water depth after the jump and head loss in the jump.

d- What would be the regime of the flow at the following locations (assume the kinematic viscosity as $1.53*10^{-5}$ m/s).

i- upstream the spillway,

ii- downstream of the spillway and

iii- at the end of the jump.

Question no. 6 (20%)

a- Explain the term "flow regime" in open channel, using a diagram.

b- Explain the f-R relationship in open channel, using a diagram.

c- Derive the Chezy's equation for uniform flow using two approaches.

d- Give few examples of RVF in open channels.

e- Explain the effect of bed contraction on the two alternate depths in a rectangular channel, using neat sketches.

$E - y_1 + \frac{V^2}{2}$

With our best wishes

بسم الله الرحمن الرحيم

Final 2008

Q (1):

لايغنى { Pump
Flow
Modelling

(a) Factors affecting velocity dist.

$$V = \frac{1}{n} \cdot R^{2/3} \cdot S^{1/2}$$

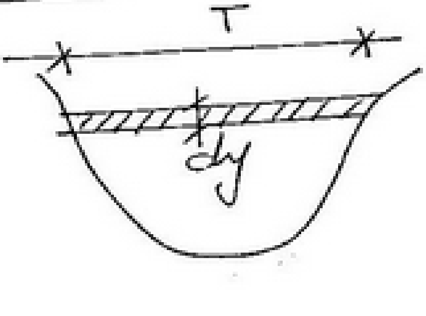
١- معامل الخشونة داخل المجرى .
٢- ابعاد القطاع المائى .
٣- شكل القطاع .
٤- وجود عوائق داخل المجرى المائى .
٥- درجة لزوجة الماء .

(b) Dynamic equation اثبات

هام

من المرجع

(c)



$$dA = T \cdot dy$$

$$\frac{dA}{dy} = T$$

$$E = y + \frac{V^2}{2g}$$

A'

$-2A^{-3}$

$$E = y + \frac{Q^2}{2gA^2}$$

$\frac{-2}{A^3} \cdot \frac{dA}{dy}$

for E_{min} $\frac{dE}{dy} = 0$

$$0 = 1 - \frac{\cancel{2} Q^2}{\cancel{2} g A^3} \frac{dA}{dy}$$

$$1 = \frac{Q^2 \cdot T}{g \cdot A^3} \longrightarrow (1)$$

$$\therefore \frac{Q^2}{g} = \frac{A^3}{T} \quad \text{at } y = y_c$$

from (1) $Q^2 = \frac{g \cdot A^3}{T}$

$$\therefore E_{min} = y_c + \frac{\cancel{g} \cdot A^{\cancel{3}}}{2\cancel{g} \cdot \cancel{A^2} \cdot T}$$

$$= y_c + \frac{A}{2T}$$

$$\because \frac{A}{T} = y_h$$

$$\therefore E_{min} = y_c + \frac{y_h}{2} \quad \#$$

(d):

methods for flow measurement

1- Critical depth method
(hump , Contraction , brink)

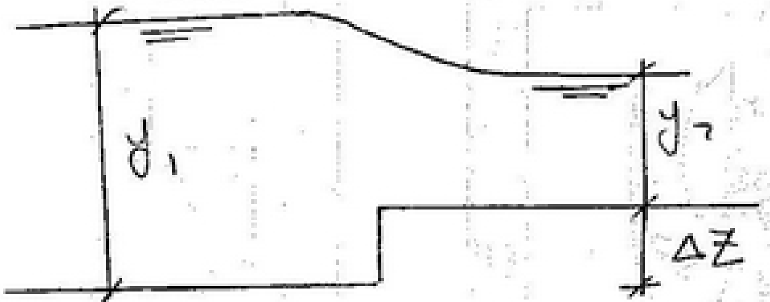
2- weirs.

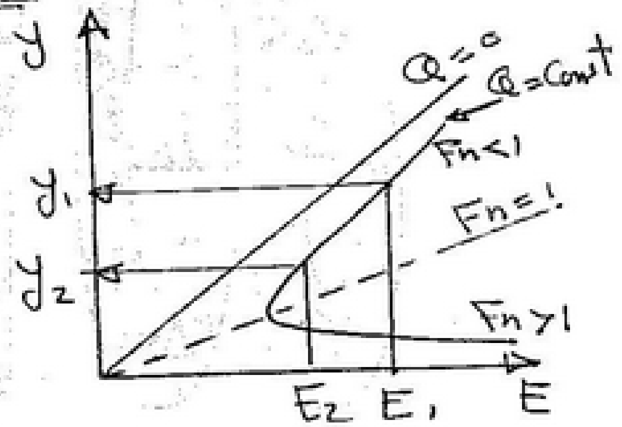
3- gates.

4- rediation method.

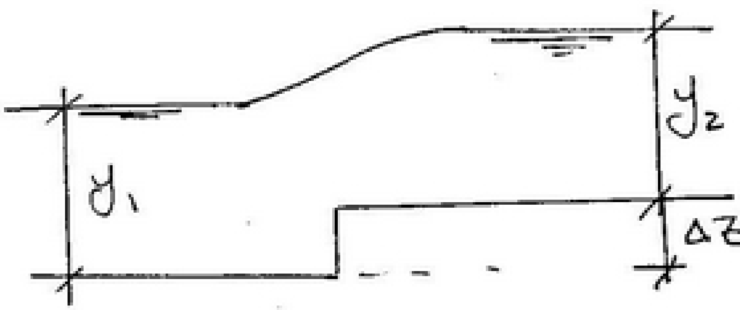
(e):

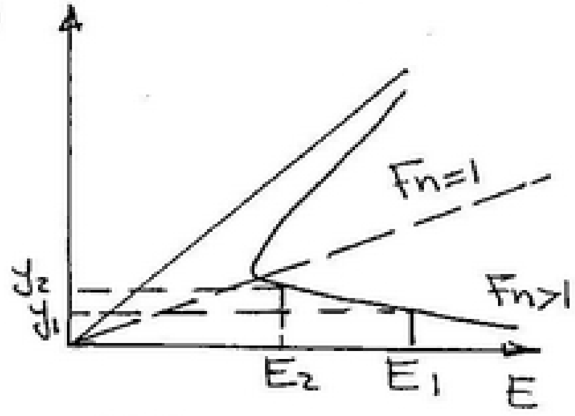
hump - subcritical





Super-critical





$Q.(2):$

$(i):$

$$\overset{F \times V}{Power} = f(Q, H, g, \mu, \rho, N, D)$$

- No. of variables = 8
- No. of repeated dim. = $\boxed{3}$
- No. of π = 8 - 3 = 5

$$F.L.T^{-1} = L^3.T^{-1}, \underline{L}, L.T^{-2}, \overset{\mu}{F.L^{-2}.T}$$

$$\overset{\rho}{F.L^{-4}.T^2}, \boxed{N}, \underline{L}$$

$$\therefore \pi_1 = g^a.\mu^b.D^c, P$$

$$\pi_2 = g^a.\mu^b.D^c.Q$$

$$\pi_3 = g^a.\mu^b.D^c.H$$

$$\pi_4 = g^a.\mu^b.D^c.\rho$$

$$\pi_5 = N$$

ملحوظة

هناك بعض المتغيرات ليس لها وحدات قياس، بالتالي ليس لها ابعاد عند دخولها في مسأله تعتبر π منفصله مثل

N : عدد اللفات

θ : زاويه الحبل

$$\pi = \theta \quad , \quad \pi = N$$

$$\therefore \quad \pi_1 = g^a \cdot \mu^b \cdot D^c \cdot P$$

$$F^0 \cdot L^0 \cdot T^0 = (L \cdot T^{-2})^a \cdot (F \cdot L^{-2} \cdot T)^b \cdot (L)^c \cdot (F \cdot L \cdot T^{-1})$$

$F: \; 0 = b + 1 \quad \Rightarrow \quad b = -1$

$T: \; 0 = -2a + b - 1 \quad \Rightarrow \quad a = -1$

$L: \; 0 = a - 2b + c + 1$

$0 = -1 + 2 + c + 1 \quad \Rightarrow \quad c = -2$

$$\pi_1 = g^{-1} \cdot \mu^{-1} \cdot D^{-2} \cdot P$$

$$\pi_1 = \frac{P}{g \cdot \mu \times D^2}$$

Q (3) :

(i) Factors affecting Manning Coff.

$$Q = \frac{1}{n} \cdot \frac{A^{5/3}}{P^{2/3}} \cdot S^{1/2}$$

١- صقل قاع القناه .

٢- التعرجات بالمجرى المائى .

٣- ابعاد المجرى المائى .

٤- نوع المواد الموجودة على حدود المجرى المائى .

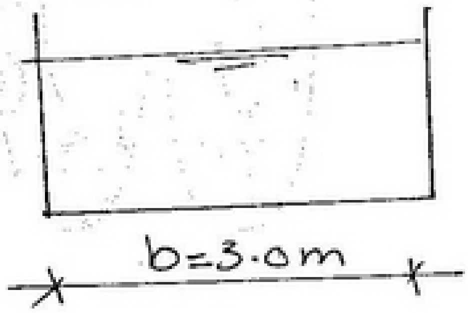
٥- وجود حشائش .

٦- وجود عوائق .

(ii)

$Q = 2.4 \ m^3/s$

$y = 0.7 \ m$



Req. :

a - $E = ??$ at $y = 0.7m$

b - y_c

c - state of flow $F_n = ??$

d - alternative depth of 0.70m

e - n = 0.015 , S_c = ??

Sol.:

(a) $$E = y + \frac{V^2}{2g}$$

$$V = \frac{Q}{A} = \frac{2.4}{3 \times 0.7} = 1.14 \, m/s$$

$$E = 0.7 + \frac{(1.14)^2}{2 \times 9.81} = 0.77 \, m$$ #

(b) $$y_c = \sqrt[3]{q^2/g}$$

$$q = Q/b = \frac{2.4}{3} = 0.8 \, m^3/s/m$$

$$y_c = \sqrt[3]{\frac{0.8^2}{9.81}} = 0.4 \, m$$ #

(c) $$F_n = \frac{V}{\sqrt{g \cdot y}}$$

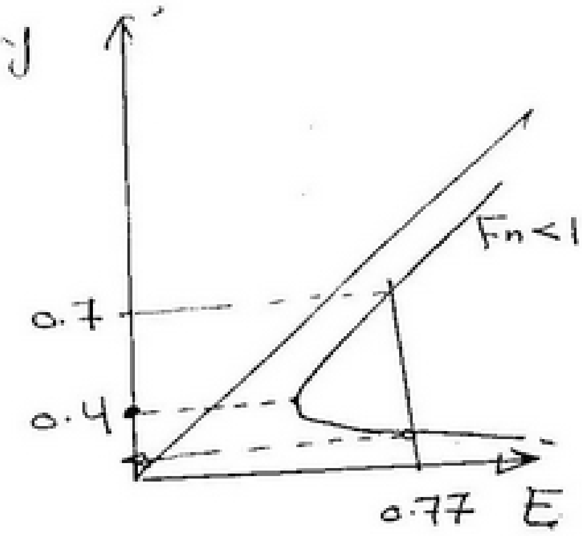
$$F_n = \frac{1.14}{\sqrt{9.81 \times 0.7}} = 0.43 < 1$$

sub. critical

#

(d)

$$E = y_2 + \frac{Q^2}{2gA^2}$$



$$\therefore A = y_2 \times b = 3y_2$$

$$0.77 = y_2 + \frac{(2.4)^2}{2 \times 9.81 \times (3y_2)^2}$$

$$0.77 = y_2 + \frac{0.032}{y_2^2}$$

y_2	0.3	0.35	0.25	
R.H.S	0.65	0.61	0.76	

$$y_2 = 0.25 \text{ m} \ \#$$

(e): $n = 0.015$ $S_c = ??$

$$\therefore Q = \frac{1}{n} \cdot \frac{A_c^{5/3}}{P_c^{2/3}} \cdot S^{1/2}$$

$$A_c = 3 \times 0.4 = 1.2 \text{ m}^2$$

$$P_c = 3 + 2 \times 0.4 = 3.8 \text{ m}$$

$$2.4 = \frac{1}{0.015} \times \frac{(1.2)^{5/3}}{(3.8)^{2/3}} \times S_c^{1/2}$$

$S_c =$ #

Q (4) :

(i) تصنيف المنحنيات

M =

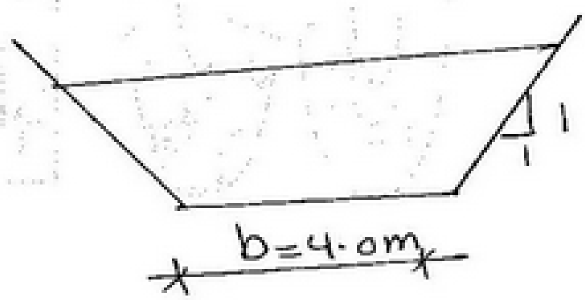
C =

S =

A =

H =

(ii) :



$S_o = 0.00015$

$Q = 2.485 \ m^3/s$

$n = 0.02$

Req.: - Classify profile

- distance 0.9 m → 0.5 m

- How to improve accuracy

Sol.:

$y_n = 0.90$ m

$\because \frac{Q^2}{g} = \frac{A^3}{T}$

$A = (4 + y_c) y_c$

$T = 4 + 2y_c$

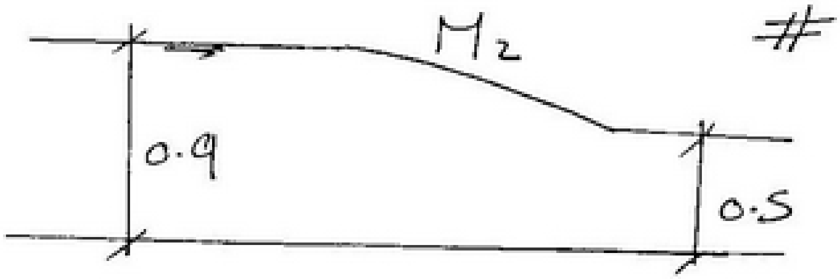
$$0.629 = \frac{(2.485)^2}{9.81} = \frac{[(4+y_c)y_c]^3}{[4+2y_c]}$$

y_c	0.5	0.4	0.3	
R.H.S	2.27	1.14		

بالملاحظة من الجدول

for $y_n > y_c$

(Mild)



by using direct step method

$$\Delta x = \frac{\Delta E}{\Delta S'}$$

$$\Delta E = E_2 - E_1$$

$$\Delta S' = S_o - S_{E\,av.}$$

$$A = (b + zy)y$$

$$- A = (4 + y)y$$

$$- P = 4 + 2y\sqrt{1+1^2}$$
$$= 4 + 2.82y$$

$$E = y + \frac{V^2}{2g}$$

$$S_E = \frac{n^2 \cdot V^2}{R^{4/3}}$$

sec	y	A	P	V (Q/A)	E	ΔE	R (A/P)	S_E	$S_{E av.}$	ΔS	ΔX
1	0.9	4.41	6.54	0.56	0.92		0.67	2.1×10^{-4}			
						0.36			8.65×10^{-4}	7.15×10^{-4}	503.5 m
2	0.5	2.25	5.41	1.10	0.56		0.42	1.53×10^{-3}			

وعليه تزداد دقة الحسابات بزيادة عدد الشرائح المستخدم

بسم الله الرحمن الرحيم

Final 2008 Cont.

Q (5):

(a) uses of hydraulic jumb.

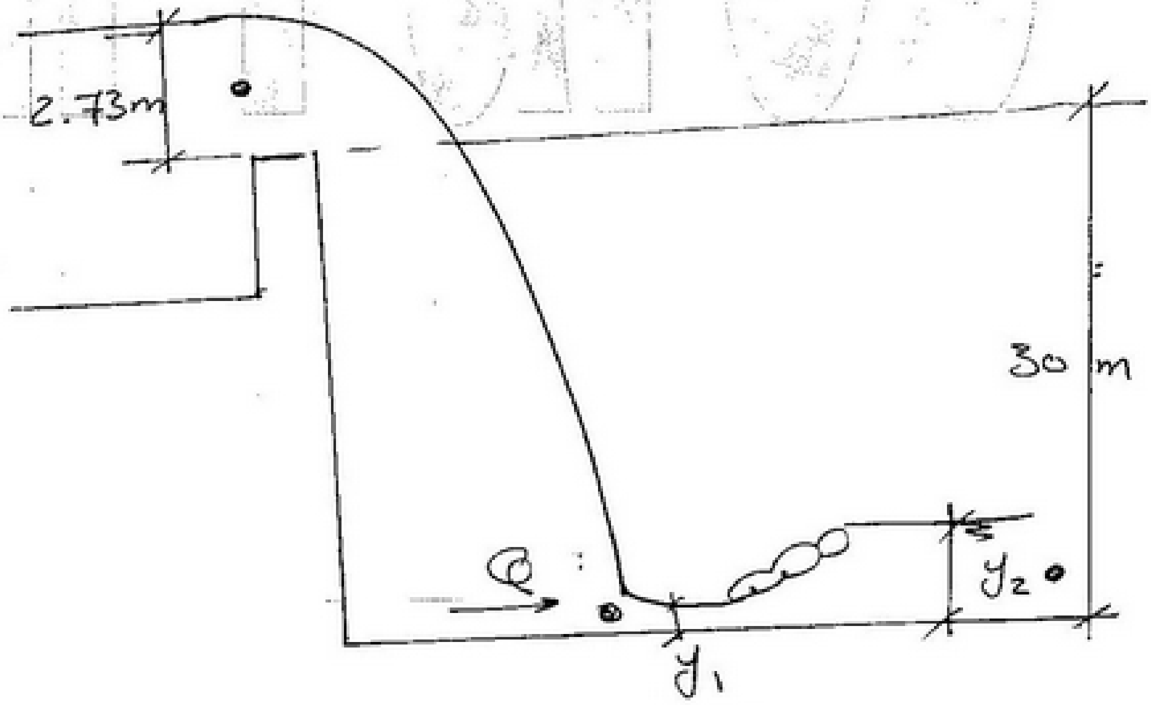
١- تشتيت الطاقة الزائده بالمجرى المائي.

٢- خلط المواد مع الماء.

٣- زيادة محتوى الهواء داخل الماء.

٤- تقليل احتمال حدوث نحر بالمجرى المائي.

(c):



(d):

$Q = 10 \ m^3/s/m'$

$\nu = 1.53 \times 10^{-5} \ m^2/sec.$

$$F_n = \frac{V}{\sqrt{g \cdot y}}$$

$$V = \frac{Q}{A} = \frac{10}{2.73 \times 1} = 3.66 \ m/s$$

$$F_n = \frac{3.66}{\sqrt{9.81 \times 2.73}} = 0.7 \quad < 1$$

$$R_n = \boxed{\frac{V \cdot y}{\nu}} = \frac{V \cdot R}{\nu} = \frac{V \cdot L}{\nu}$$

$$R_n = \frac{3.66 \times 2.73}{1.53 \times 10^{-5}}$$

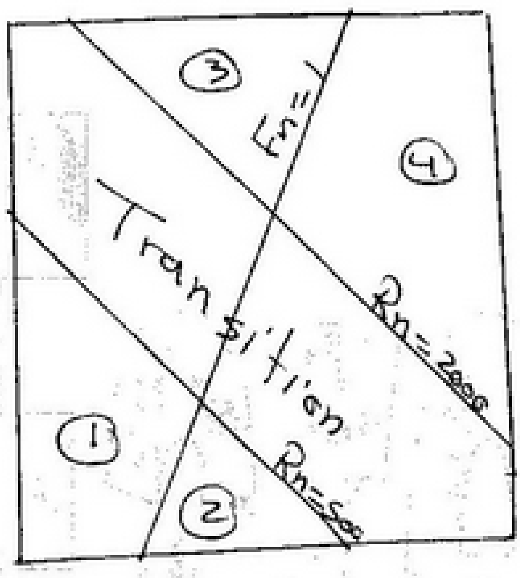
$$= 6.53 \times 10^5 \quad > 2000$$

Turbulent - subcritical

Q(6) :

(a) flow regim :

هو تصنيف يعتمد على Fn ، Rn في نفس الوقت



① Laminar - sub critical

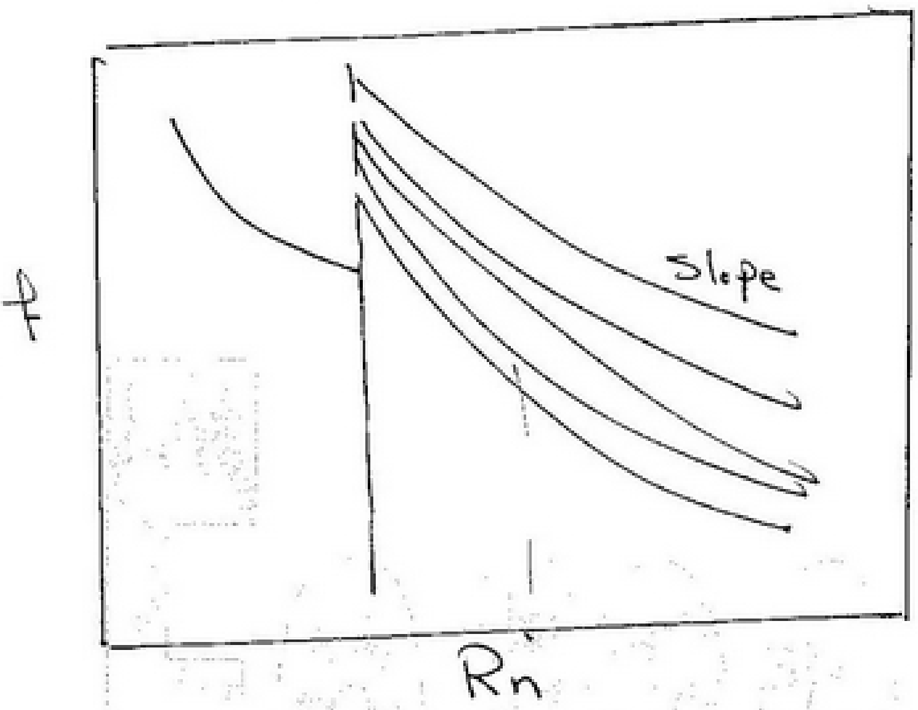
② Laminar - super critical

③ Turbulent - sub critical

④ Turbulent - super

(b) (f - Rn) diagram

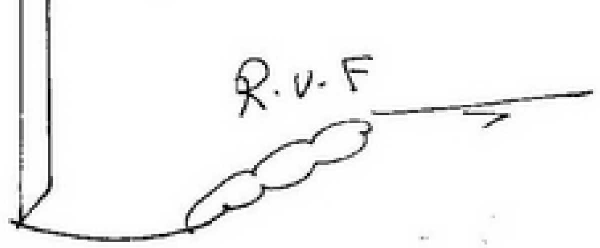
(Mody diagram)

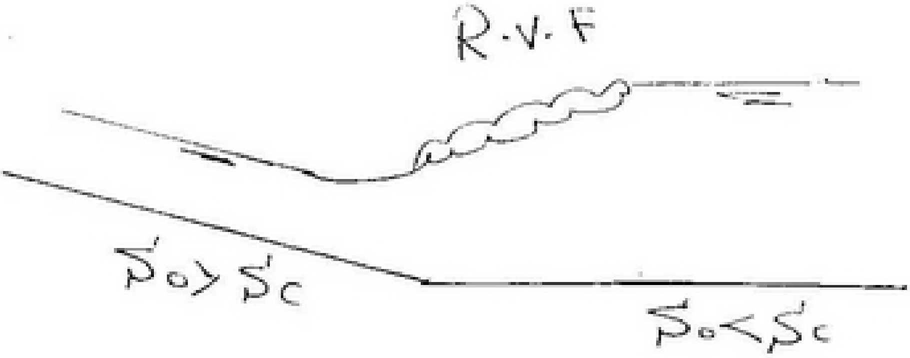


(d) example R.V.F.

D.S weir

D.S gate.

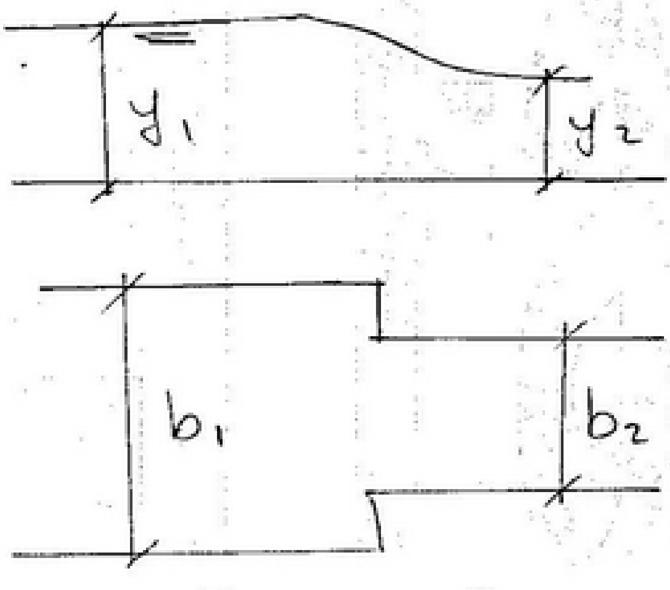


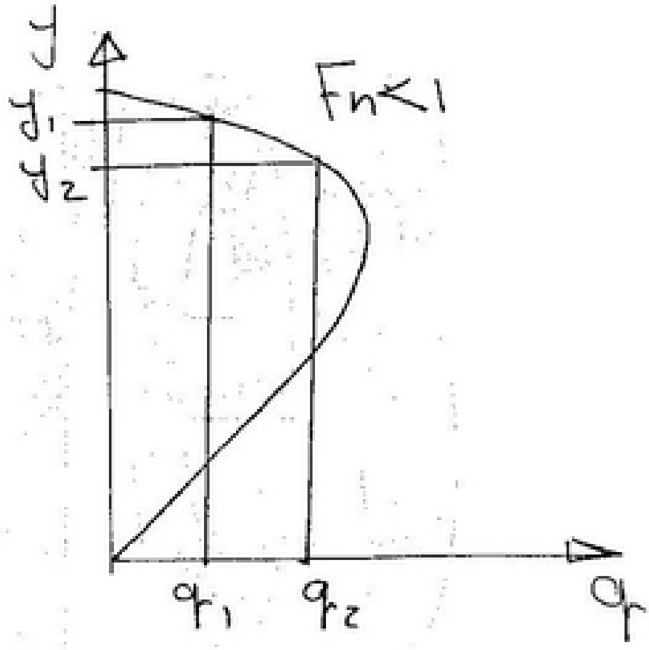


at change of slope

(e):

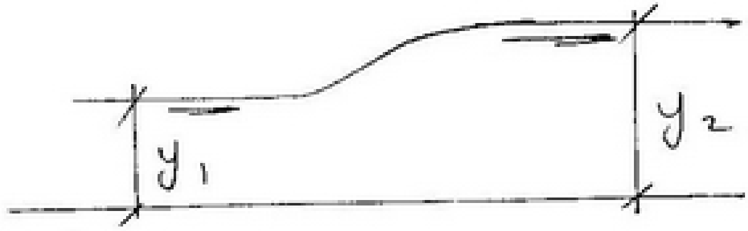
$F_n < 1$

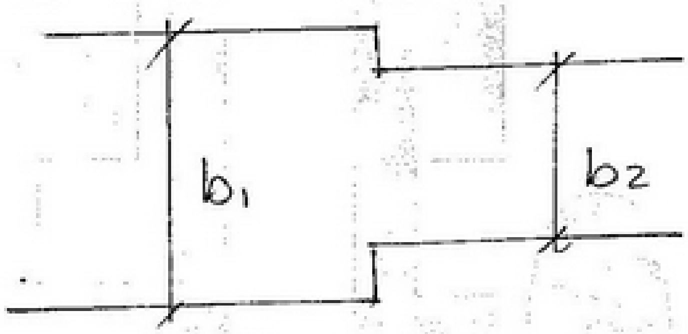


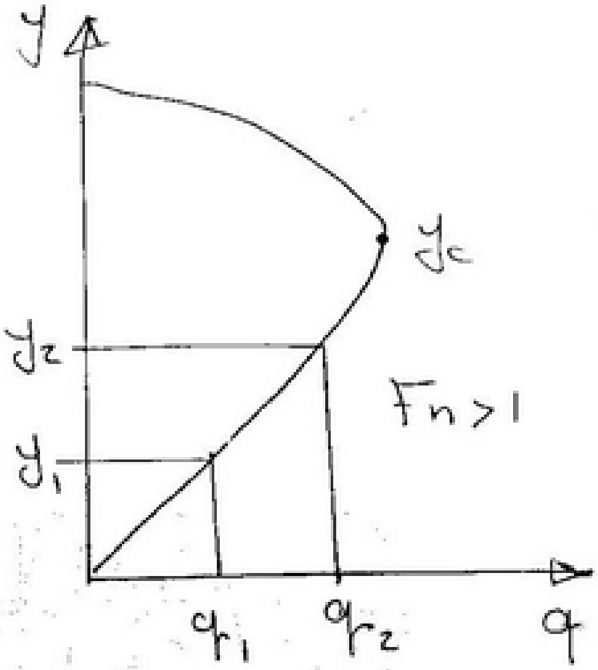


$q_1 < q_2$

Fn>1







$q_1 < q_2$